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CROP RESIDUE AND PLANT HEALTH: RESEARCH OVERVIEW AND IMPLICATIONS FOR NO-TILL

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Introduction

Over the past four decades, researchers have examined the effects of crop residue on the growth of plants. Results have been mixed and sometimes controversial. This article summarizes those findings and draws conclusions for our local cropping systems.

Residues have been shown to damage wheat and other crops in both laboratory and greenhouse studies (Elliot et al., 1978; Patrick and Toussoun, 1965). Toxic effects can be simulated by simple water extractions and also by more elaborate incubations and extractions of residue (Cochran et al.,1977; Kimber 1973; Lodhi et al., 1987; Martin et al., 1990; Mason-Sedun et al., 1986). Toxic substances, from simple acetic acid (vinegar) to hormones, sometimes originate with microbial activity but can also be present under sterile conditions (Kimber, 1967; Purvis, 1990). This discussion will not distinguish between chemical toxic effects of residue and those of pathogens stimulated by the presence of residue.

Only recent, unweathered residues produce a toxic effect. Researchers have found that when kept dry, residue loses its phytotoxic potential in a year or less (Kimber 1967; Mason-Sedun et al., 1986; Purvis and Jones, 1990). When fresh residues become moist and start to decay, the length of time residue has negative effects on plant growth ranges from a few weeks to several months. After this initial period of negative impact, some residues have shown a yield-enhancing effect. If a layer of soil separates residue from plants, the toxic effects are usually diminished or eliminated altogether. The amount of sand, clay, and organic matter in a soil can influence the toxicity of residues (Patrick and Toussoun, 1965; Purvis and Jones, 1990).

Growth impairments relate to germination, emergence, growth rates, or tillering. Often the responses are very specific, for example, no effect on germination but a definite effect on shoot growth (Mason-Sedun, 1986). A recently completed greenhouse study reported that wheat seedling height was reduced by 20 percent 20 d after planting when 3-mo-old wheat residues were placed about an inch below the seed (Stewart Wuest, unpublished data, 1998) (Fig. 1). There was also a delay in the developmental rate of the seedlings whose roots grew into fresh wheat residue.

The effects of residue on plant health are very complex. Dozens of substances have been extracted from fresh residues and shown to inhibit growth of plants in the laboratory. These substances can either stimulate or inhibit microbial growth in the soil, including microbes that are wheat pathogens. In the laboratory, residues have also been shown to make roots vulnerable to root infection and affect pathogen activity (Patrick and Toussoun, 1965).

In field studies it becomes more difficult to demonstrate that buried residues reduce crop vigor or crop yield, but this is not surprising given the complex nature of the interactions among residues, soil, microbes, and plants. Residue from different cultivars of wheat as well as differences in the age of the residue, the moisture conditions while it aged, and soil type produce varying amounts of toxicity.

There are other crop-health problems that may be caused by the presence of residue in the seed bed: disease, light interference, difficulty in seed placement, and immobilization of nutrients (Elliott et al., 1981; Wilkins et al., 1988). Understanding why certain plants in a crop stand are less vigorous or more prone to diseases becomes very challenging.

Given the number of questions about the role of residue in plant health, it might seem difficult to learn how to manage residues in a way that both protects soil productivity and maximizes crop production. There are, however, some useful conclusions we can draw from what we know about the potential toxicity of residues.

Conclusions

Residue toxicity is only likely to cause problems in fall-seeded crops because this is when we have large quantities of unweathered residues. In the Columbia Basin there is little moisture to start decomposition of residues between summer harvest and fall planting. Annual spring cropping systems should not encounter much, if any, phytotoxicity of residue because the residue has been well leached and partially decomposed. Disease problems found in annual winter wheat cropping systems may be due to toxins, as well as pathogens found in unweathered residues. These residues are often plowed under the surface where they are intercepted by the roots.

There are both advantages and disadvantages to fall no-till systems regarding the potential phytotoxic properties of fresh residues. No-till presents the opportunity to plant into ground with no buried residue. As long as seeding equipment does not bury residue and keeps it from contacting the seed, it should be possible to avoid problems with germination and prevent growing roots from encountering toxins.

Fresh residues left on the surface of the soil remain a concern. Should these be pushed away from the seed row, or is an inch or so of soil above the seed enough to absorb and detoxify any leachates from the wet residues above the seed? There may be other reasons to clear residue from the seed row when planting fall wheat. Research at Pendleton has demonstrated that standing stubble can reduce light penetration into the seed row enough to reduce seedling vigor and tillering of winter wheat (Wilkins et al., 1988). Whether this results in a reduction in yield will depend on circumstances later in the growing season.

The risks and benefits of not disturbing standing stubble and residue on the soil surface need to be weighed. In many areas of the United States, standing stubble catches blowing snow and makes an important contribution to soil water. This may not be an important factor in much of the Pacific Northwest. On the other hand, ultra-low disturbance seeding systems have been credited with a reduction in weed populations. If low disturbance systems that help control weed populations can be developed for the Pacific Northwest, the weed control benefits might outweigh the shading or phytotoxic effects of surface residue over the seed row. Standing stubble may also be part of a profitable solution in areas where blowing soil degrades soil productivity and damages seedling wheat.

Loss of soil moisture by evaporation is another factor whose importance will vary in different areas. In the no-till spring cropping systems in Alberta, Canada, heavy, wet, cold soils are a major problem. In contrast, here in the Pacific Northwest, leaving residue near the seed row to reduce evaporation is an advantage when we plant fall crops into our light, dry soils.

For a cropping system as a whole, crop residue benefits soil productivity and erosion control; we would be shortsighted to view it only as a liability. Our knowledge of the potential toxic effects of residue should allow us to maximize the benefits of surface residue cover produced in no-till and avoid the hazards to plant health in fall-seeded systems.

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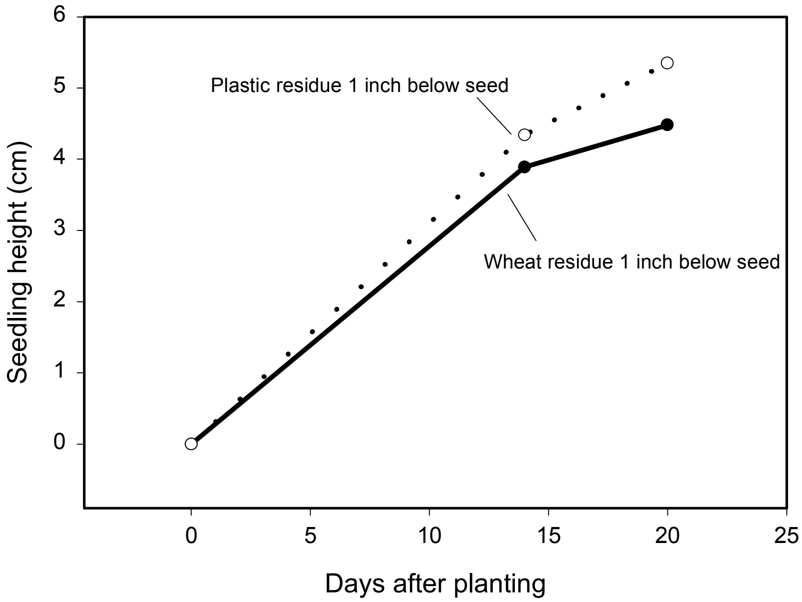

Figure 1. Height of winter wheat (Madsen) seedlings with roots growing through fresh wheat or plastic residues placed 1 in. below the seed. Pendleton, OR 1998.